Virtual Safety Laboratory

William O. Wray
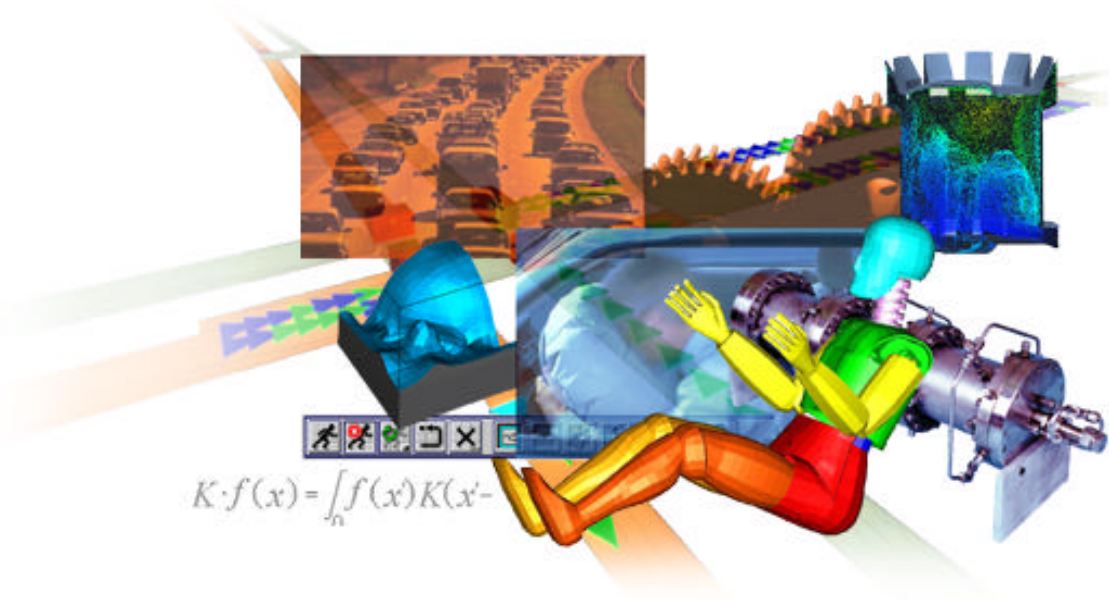
Bioscience and Biotechnology Group
Chemical Science and Technology Division

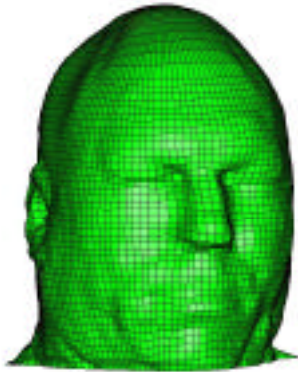**E-Mail: wray@lanl.gov**
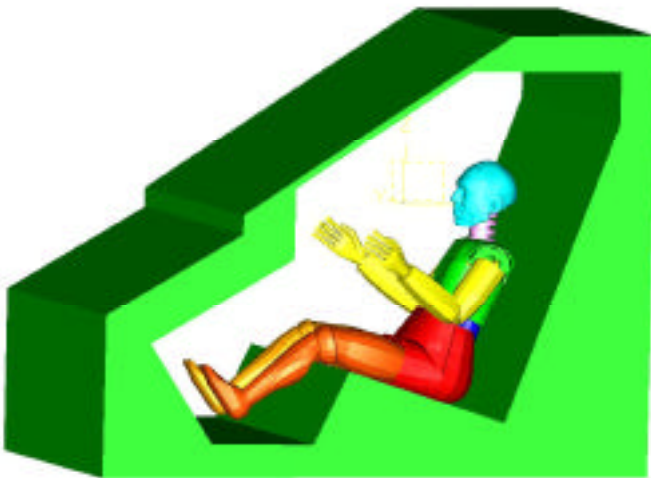**Phone: 505-667-4496**
Fax: 505-667-0851

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$$K \cdot f(x) = \int_{\Omega} f(x) K(x' - $$

A Tool for Integrated Occupant Safety Analysis

Detailed Head Model

5th %tile group south china woman with detailed head model seated in deformable test vehicle
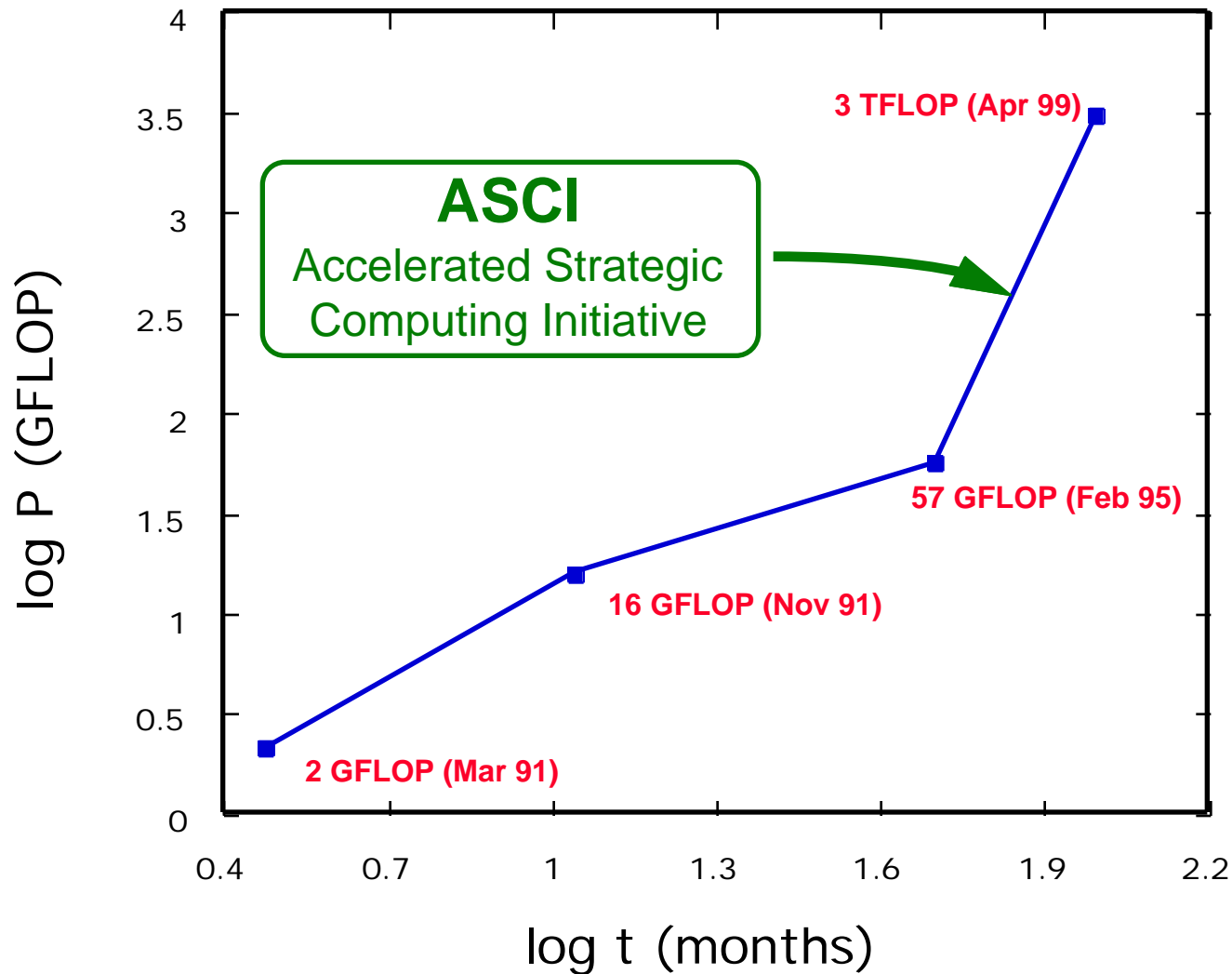
featuring:

- **Realistic human occupant models**
- **Scaleable for international anthropometry**
- **Bio-Component model substitution capability**
- **Detailed head model based on Visible Human Dataset from Natl. Lib. Med.**
- **Point & click graphical user interface**

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Why Develop a Virtual Safety Lab?

- **Recent Dramatic increases in computing power**
- **High cost of full scale crash tests**
- **Can conduct safety analysis during design phase**
- **Can investigate more combinations of parameters**
    - **Occupant size and body type**
    - **Type of collision (frontal, side, offset, etc.)**
    - **Speed of impact**
- **Can validate VSL with full scale crash test data**

Computing Power vs Time (log/log)
(SG/Cray Mainframe Computers)

3 TFLOP (Apr 99)

ASCI
Accelerated Strategic
Computing Initiative

57 GFLOP (Feb 95)
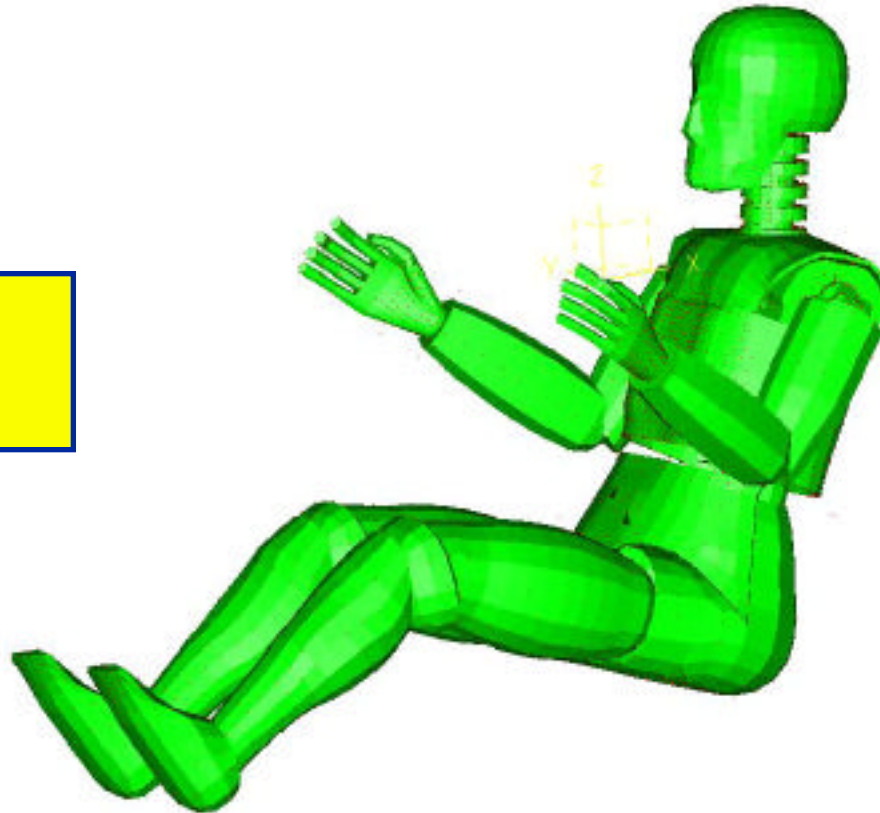
16 GFLOP (Nov 91)

2 GFLOP (Mar 91)

log P (GFLOP)

log t (months)

Finite Element Model of Hybrid III 50th %tile Male Dummy
(provided by NCAC at George Washington University)

16,000 Node Model

International Data on Anthropometry
(Jurgens et. al.)

- **19 anthropometric measurements given for**
- **5th, 50th & 95th %tile male and female members of**
- **20 geographic/ethnic groups worldwide**
- **All measurements projected to the year 2000**

North America

Latin America (Indian)

L. America (Europ.-negroid)

Northern Europe

Central Europe

Eastern Europe

South-eastern Europe

France

Iberian Peninsula

North Africa

West Africa

South-eastern Africa

Near East

North India

South India

North Asia
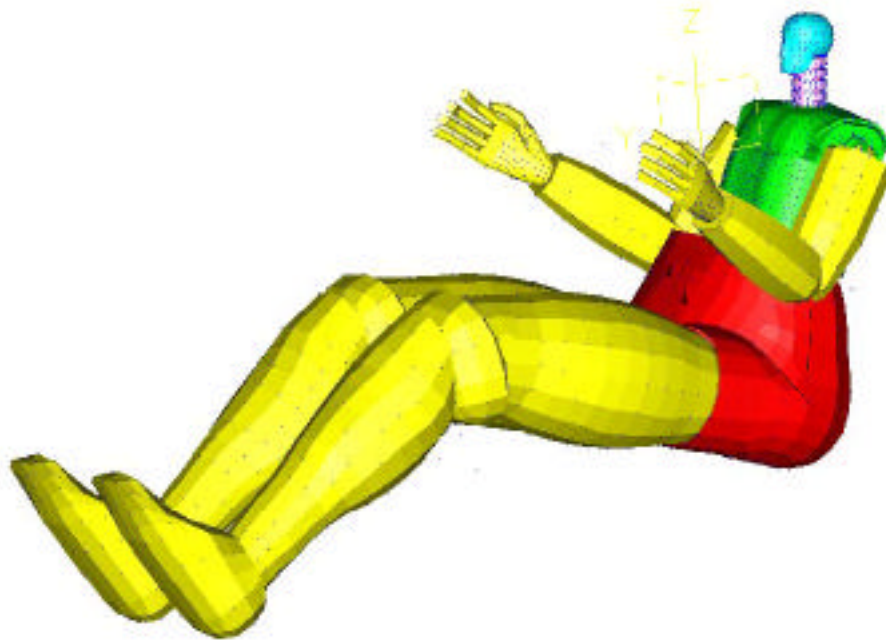
South China

South-East Asia

Australia (European)

Japan

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Anthropometric Measures Used in Hybrid III Scaling

- **Head length, breadth & circumference**
- **Shoulder breadth (bideltoid & biacromial)**
- **Forward reach (fingertips)**
- **Hip breadth (sitting)**
- **Sitting height**
- **Buttock-knee length**
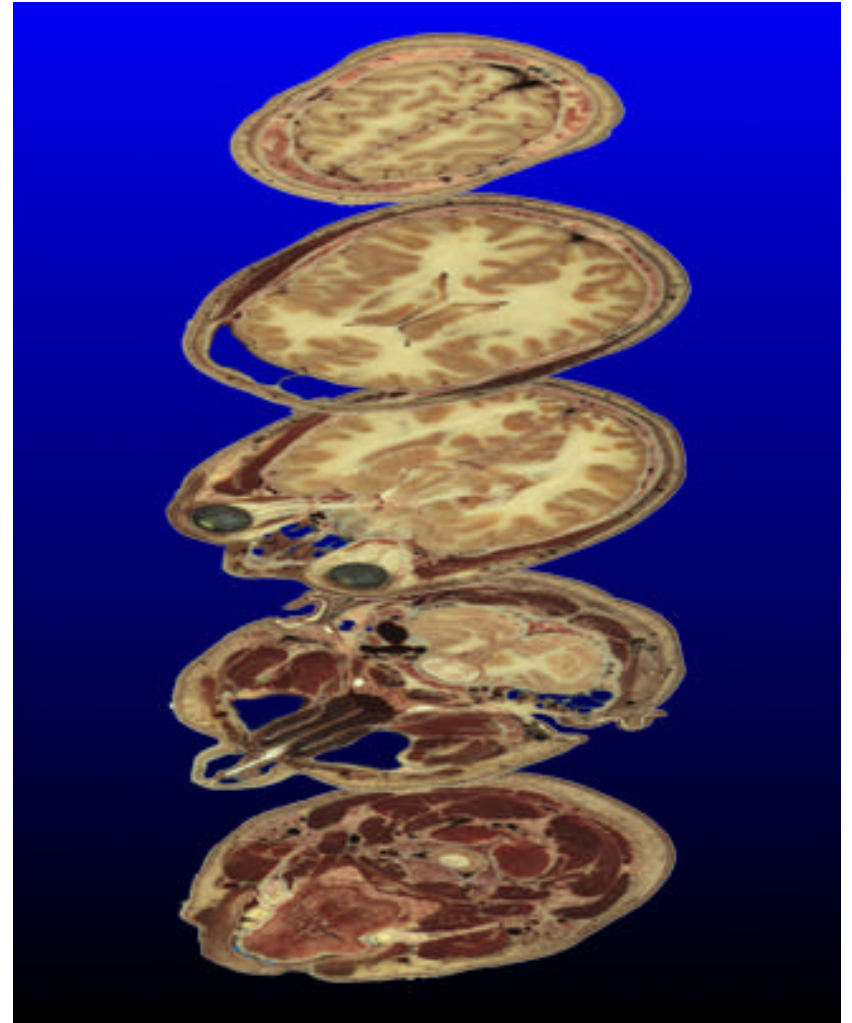- **Knee height**

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"Bigfoot" Dummy Model:
(Demonstrates Flexible Scaling Capability in VSL)

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Hybrid III Dummy Model Scaled to Represent a 5th %tile South China Female
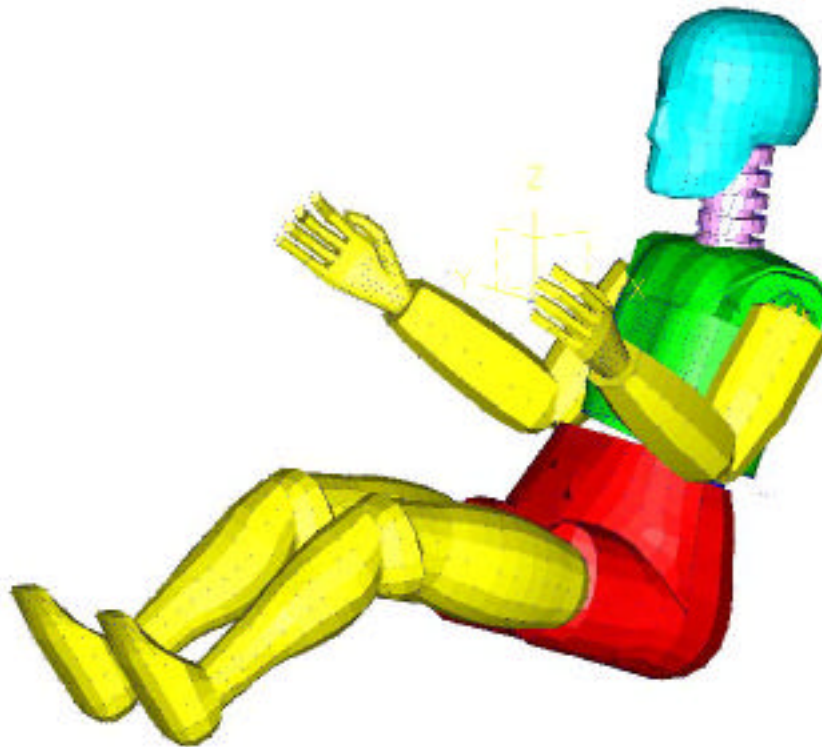
Detailed Head/Brain Model
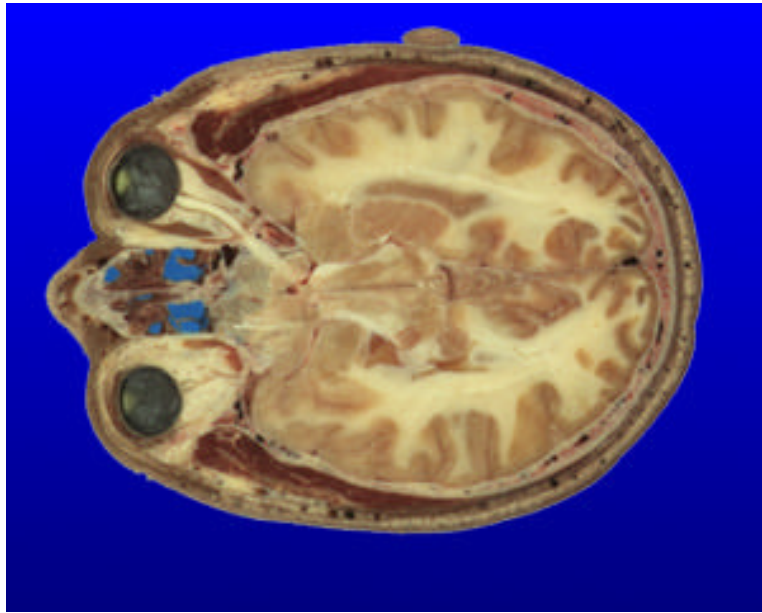
- **Generation of Detailed 3-D Head Model**
  - based on Visible Human Dataset from National Library of Medicine
  - anatomical components extracted from cryosectional images
  - 3-D model constructed from stack of vectorized components' contours

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3D Object Representing Outer Soft Tissue Layers of Human Head

(constructed from the Visible Human Dataset provided by the National Library of Medicine)

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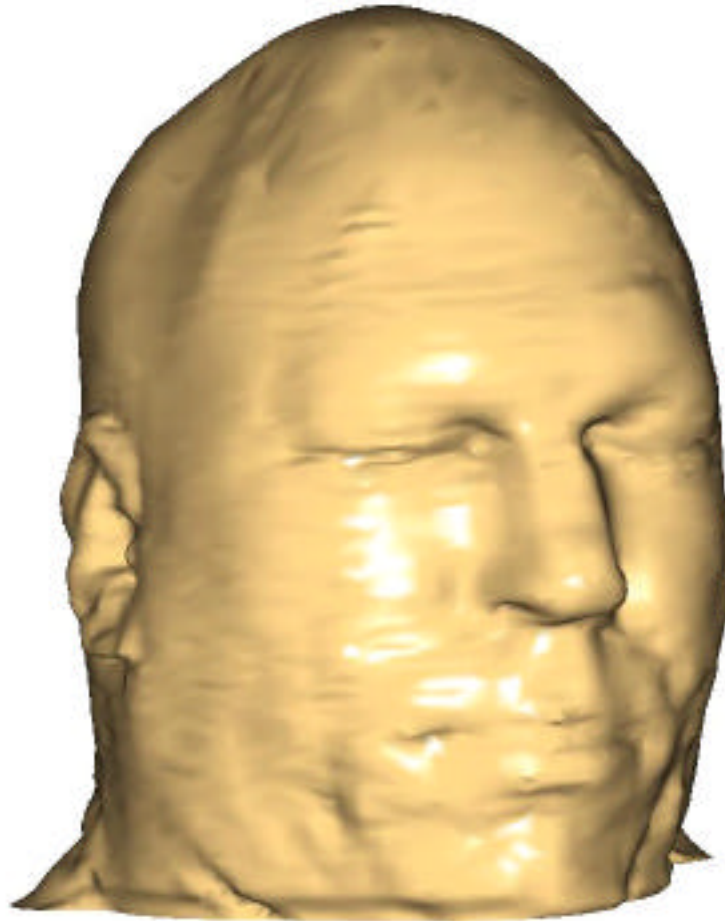
3D Object Representing the Human Skull

(constructed from the Visible Human Dataset provided by the National Library of Medicine)

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3D Object Representing the Human Brain

(constructed from the Visible Human Dataset provided by the National Library of Medicine)
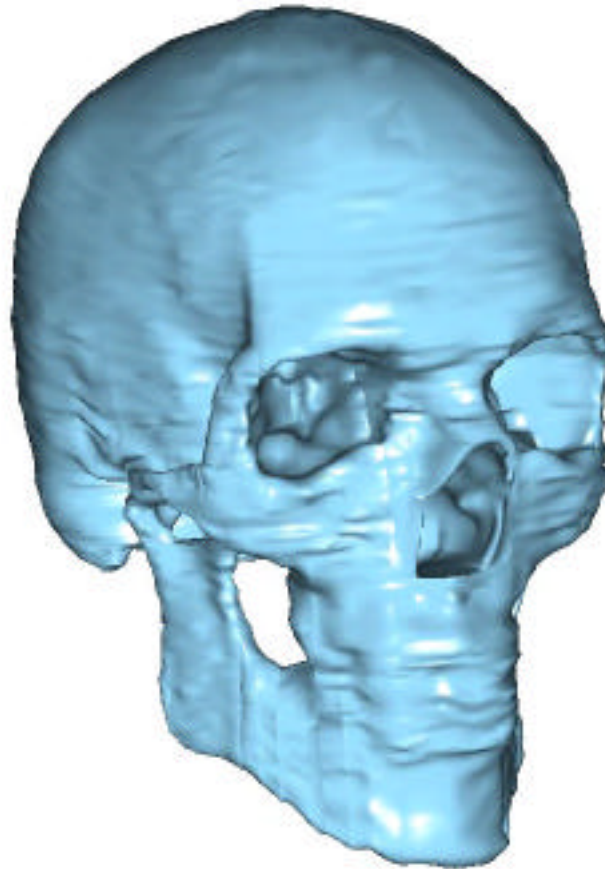
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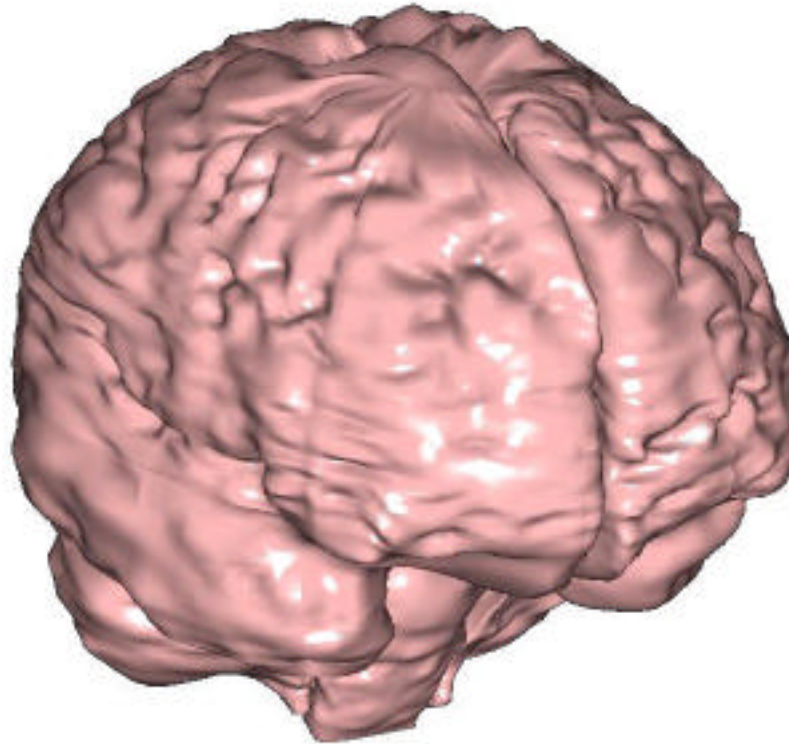
Detailed Finite Element Model of Human Head

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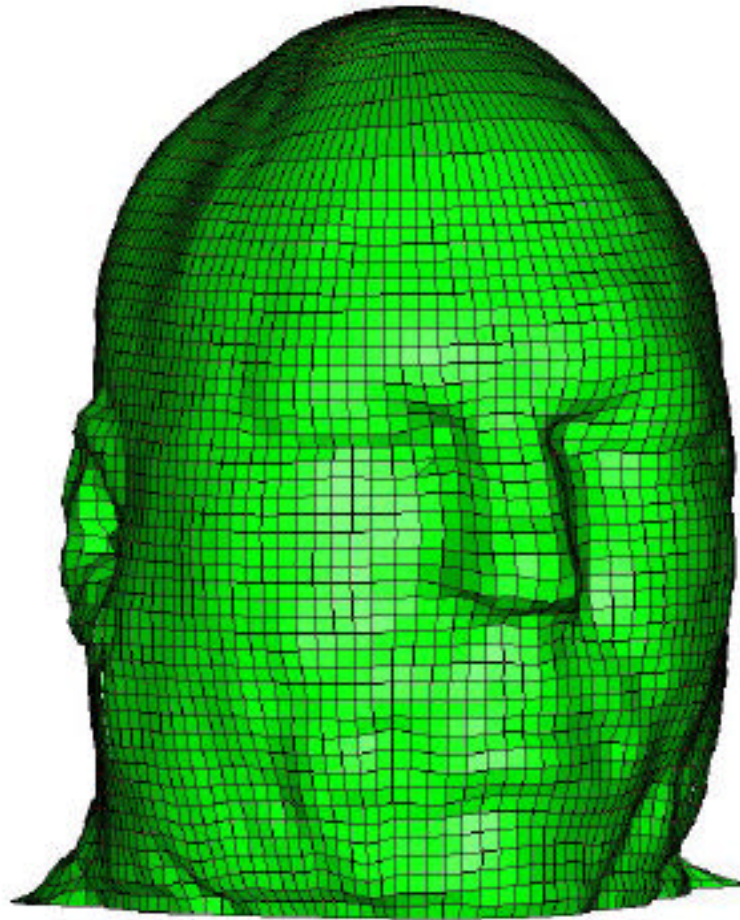
Component Model Substitution Capability
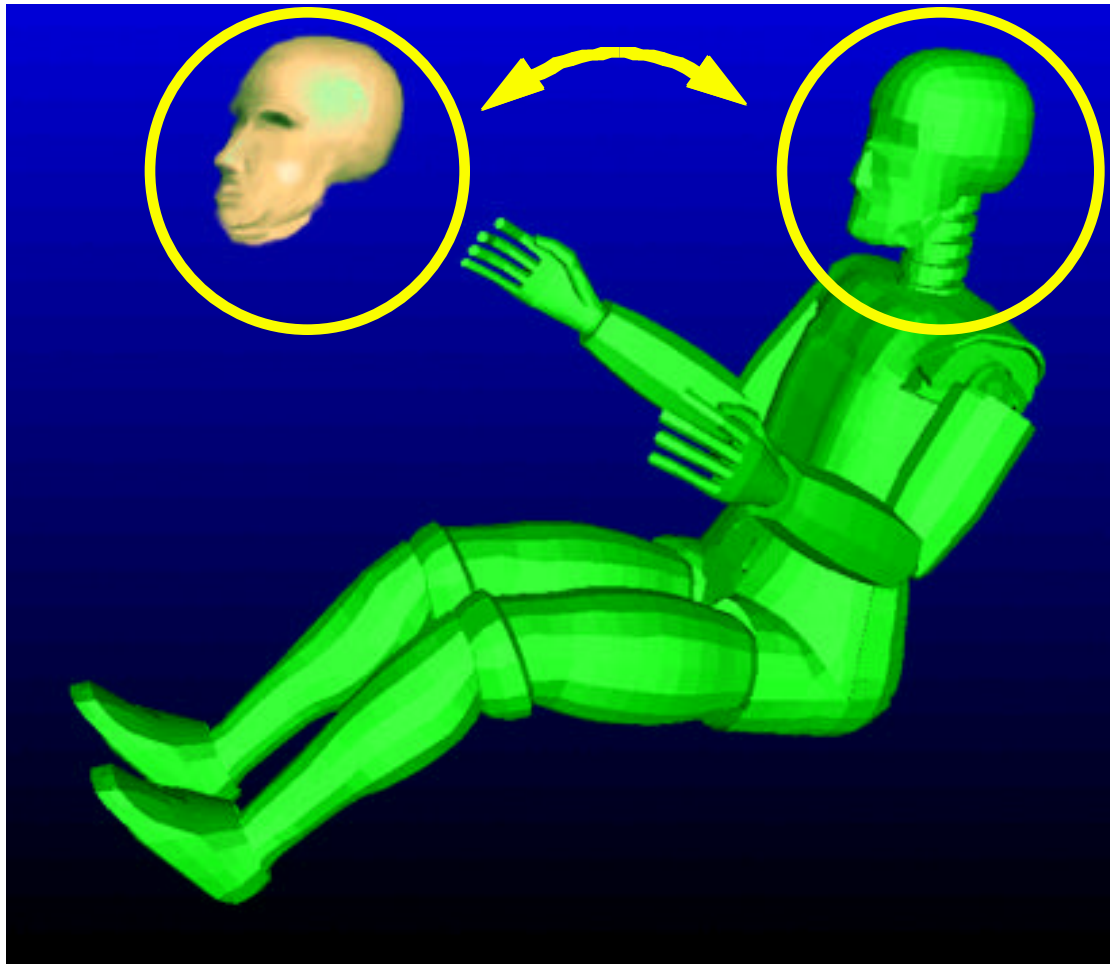
Detailed head model is substituted for the dummy head model

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VSL Graphical User Interface

- **Uses Khoros, developed by: Khoral Research, Inc.**
  Albuquerque, New Mexico

- **Provides a visual programming environment for software development.**

- **Use of "Toolboxes" promotes collaboration across and within various disciplines and domains.**
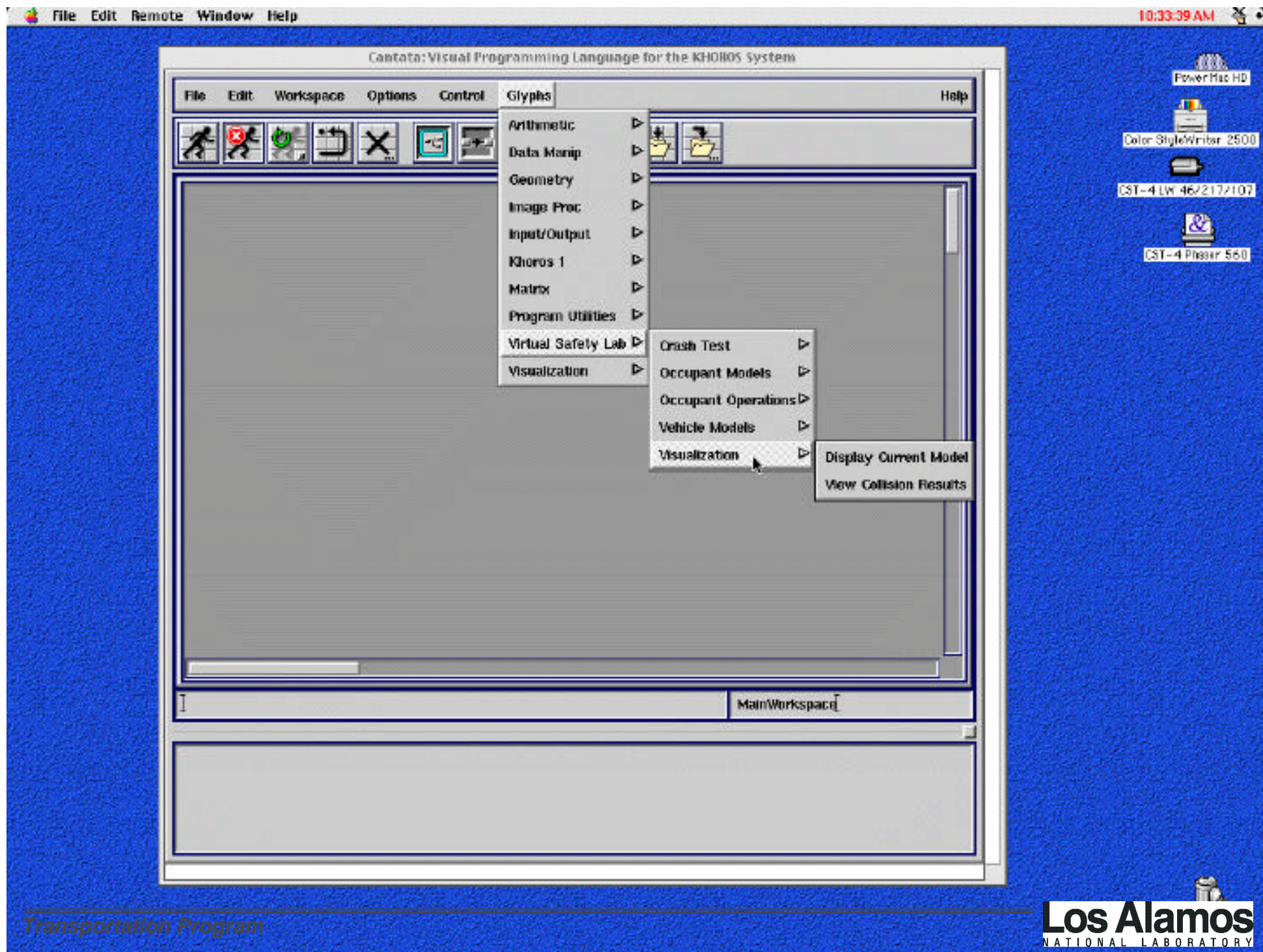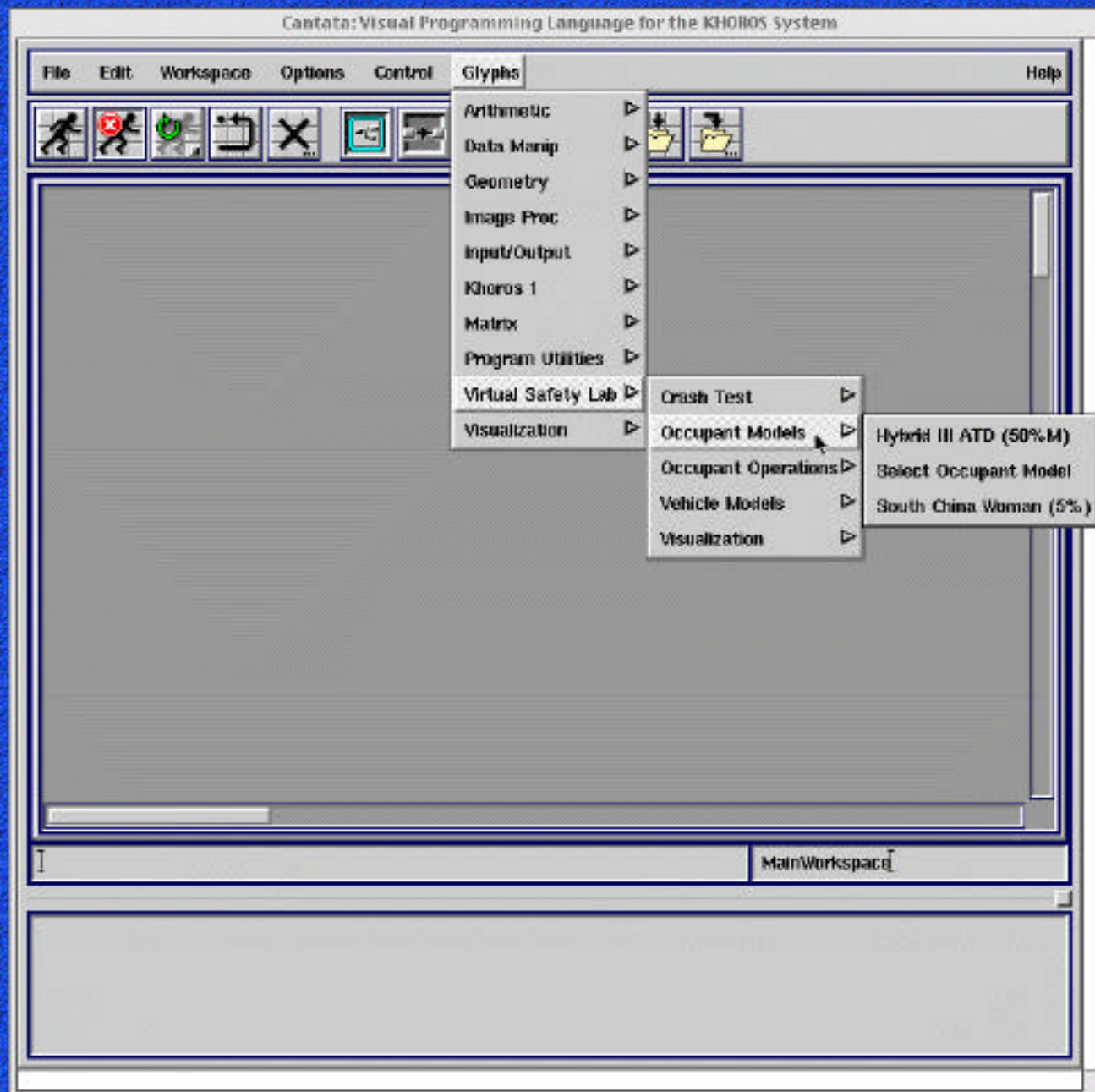
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Cantata: Visual Programming Language for the KHOROS System

File   Edit   Workspace   Options   Control   Glyphs   Help

- Arithmetic ▷
- Data Manip ▷
- Geometry ▷
- Image Proc ▷
- Input/Output ▷
- Khoros 1 ▷
- Matrix ▷
- Program Utilities ▷
- Virtual Safety Lab ▷
  - Crash Test ▷
  - Occupant Models ▷
  - Occupant Operations ▷
  - Vehicle Models ▷
  - Visualization ▷
    - Display Current Model
    - View Collision Results
- Visualization ▷

MainWorkspace

Transportation Program

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PowerMac HD

Color StyleWriter 2500

CST-4 LW 46/217/107

CST-4 Phaser 560

Cantata: Visual Programming Language for the KHOROS System

File   Edit   Workspace   Options   Control   Glyphs   Help

Specify Occupant Dimensions

Scale occupant model by specifying dimensions.

Scale occupant model by specifying dimensions.

Options ▽   Run   Help   Close

Head Circumference (in)   22.60

Head Length (in)   7.75

Head Breadth (in)   6.06

Bideltoid Shoulder Breadth (in)   16.90

Biacromial Shoulder Breadth (in)   16.90

Forward Reach (in)   32.75

Sitting Hip Breadth (in)   14.80

Erect Sitting Height (in)   34.80

Buttock-Knee Length (in)   23.30

Knee Height (in)   22.13

PowerMac HD
Color StyleWriter 2500
CST-4 LW 46/217/107
CST-4 Phaser 560

Transportation Program

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Cantata: Visual Programming Language for the KHOROS System

File Edit Workspace Options Control Glyphs   Help

Glyphs Menu		
Arithmetic	▷	
Data Manip	▷	
Geometry	▷	
Image Proc	▷	
Input/Output	▷	
Khoros 1	▷	
Matrix	▷	
Program Utilities	▷	
Virtual Safety Lab	▷	
Visualization	▷	

Virtual Safety Lab Submenu	
Crash Test	▷
Occupant Models	▷
Occupant Operations	▷
Vehicle Models	▷
Visualization	▷

Vehicle Models Submenu
Deformable Test Vehicle
Rigid Test Vehicle
Select Vehicle
User Defined Vehicle

MainWorkspace

Transportation Program
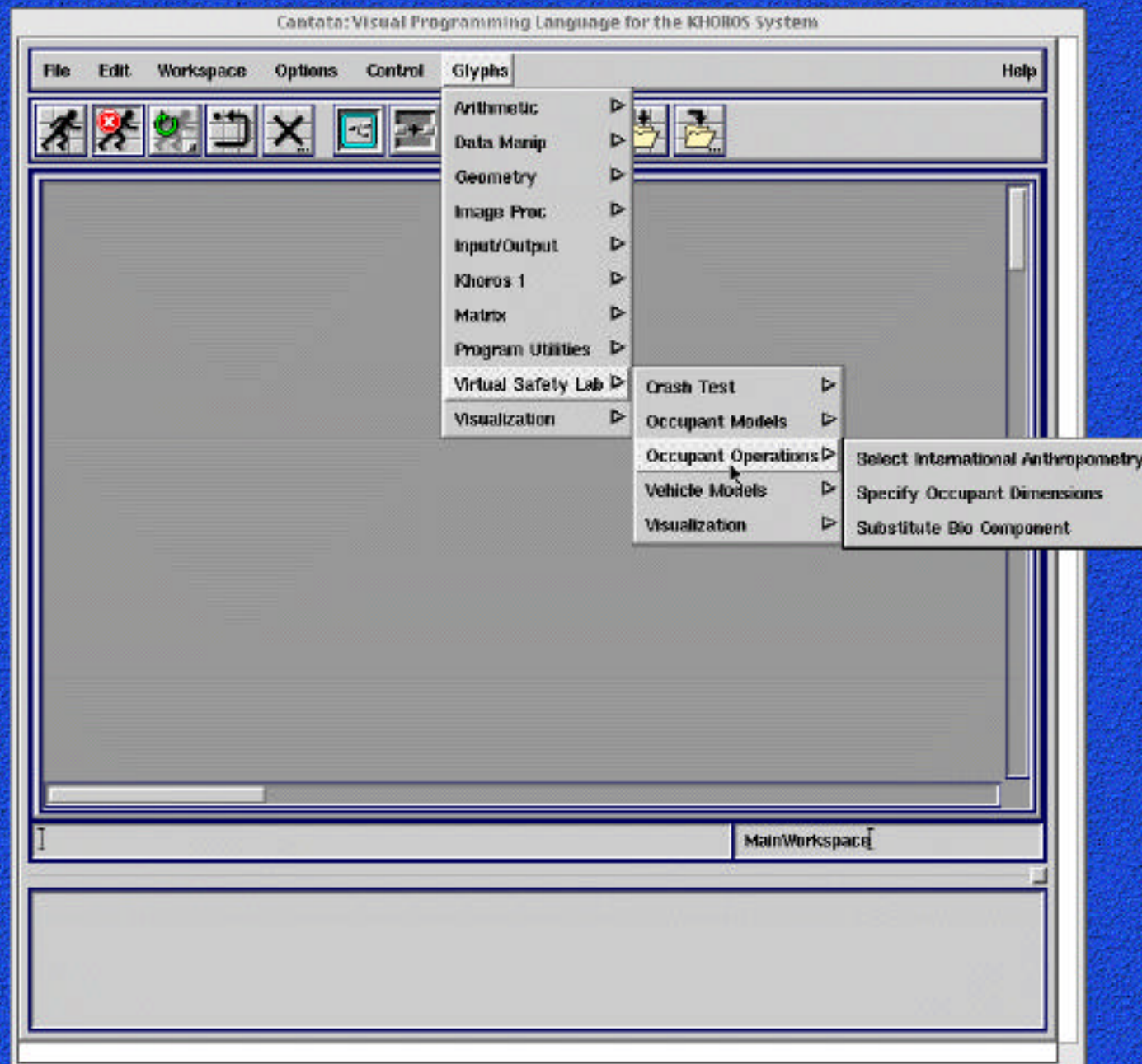
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PowerMac HD
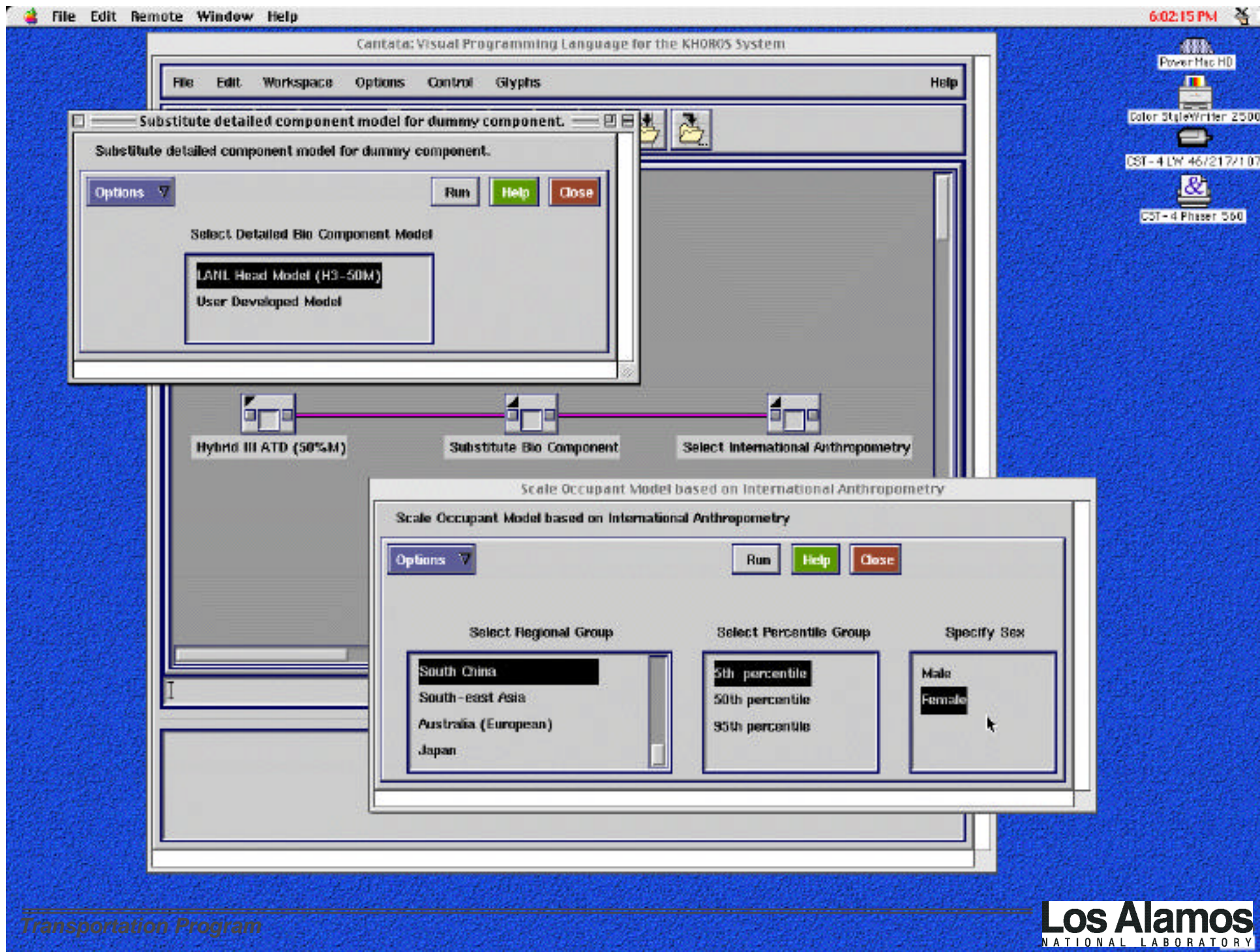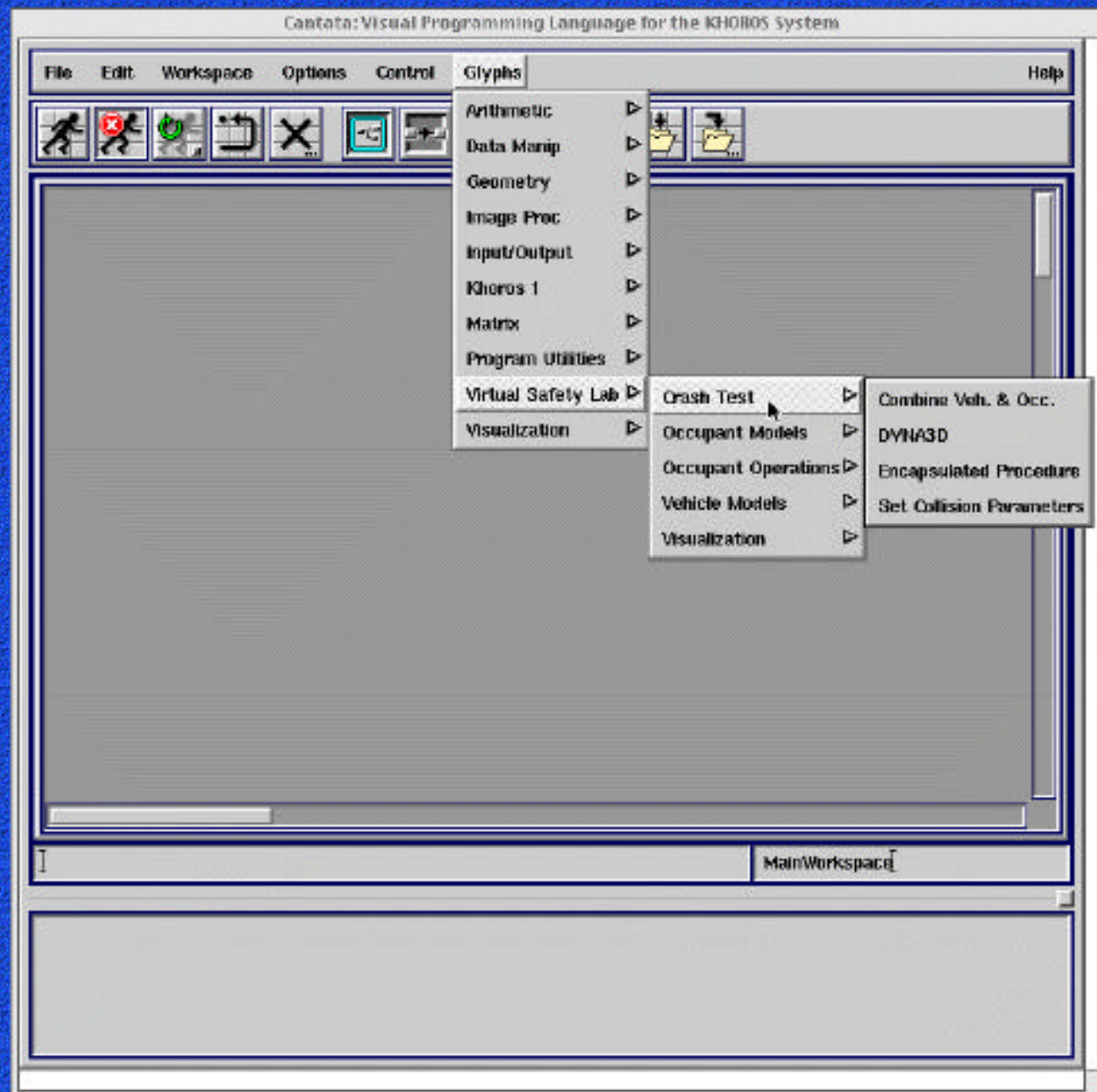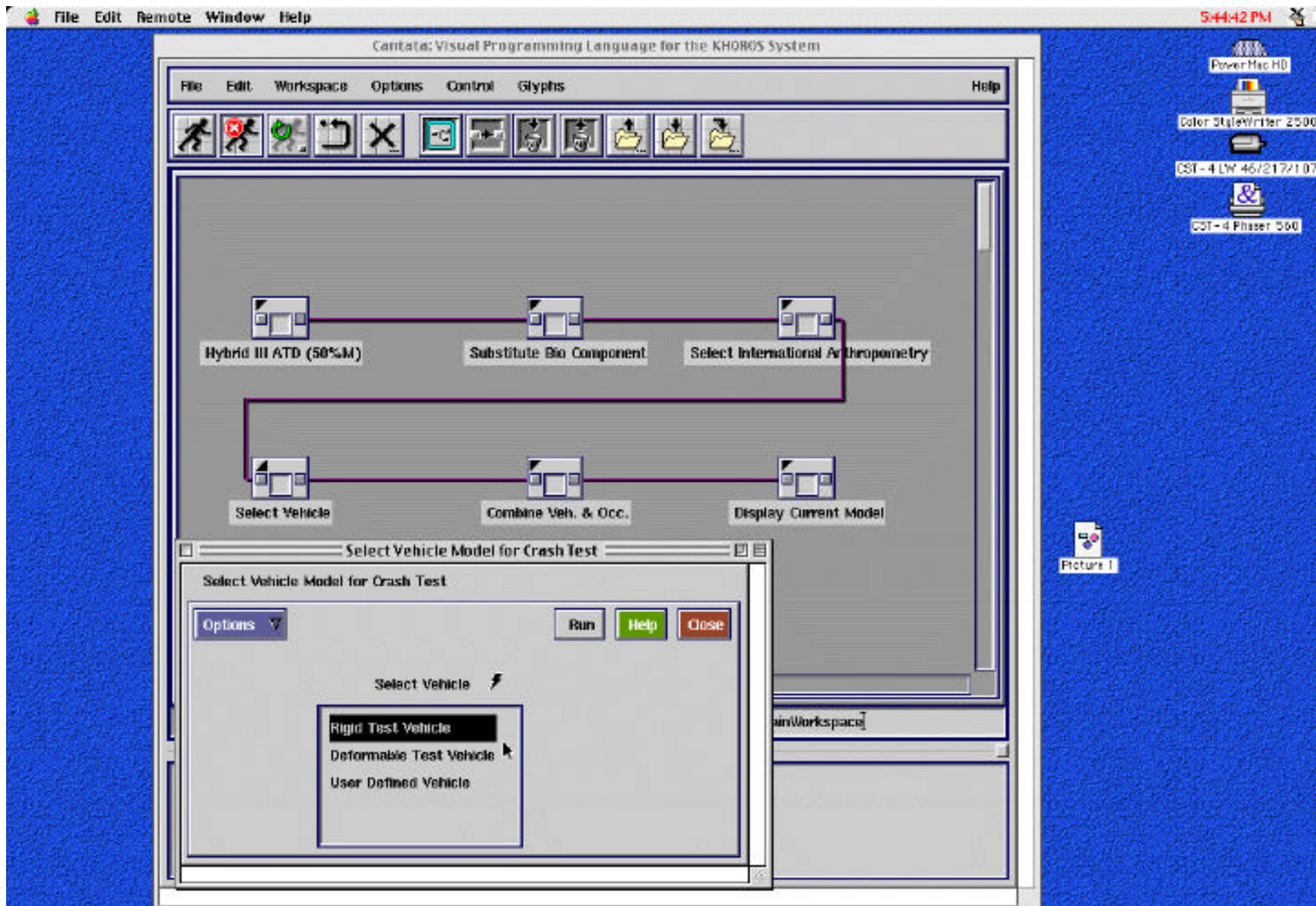Color StyleWriter 2500
CST-4 LW 46/217/107
CST-4 Phaser 560

PowerMac HD

Color StyleWriter 2500

CST-4 LW 46/217/107

CST-4 Phaser 560

Cantata: Visual Programming Language for the KHOROS System

File   Edit   Workspace   Options   Control   Glyphs   Help

Arithmetic   ▷
Data Manip   ▷
Geometry   ▷
Image Proc   ▷
Input/Output   ▷
Khoros 1   ▷
Matrix   ▷
Program Utilities   ▷
Virtual Safety Lab ▷   Crash Test   ▷   Combine Veh. & Occ.
Visualization   ▷   Occupant Models   ▷   DYNA3D
                         Occupant Operations ▷   Encapsulated Procedure
                         Vehicle Models   ▷   Set Collision Parameters
                         Visualization   ▷

MainWorkspace

Transportation Program

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Result of Executing Procedure

Cantata: Visual Programming Language for the KHOROS System

File   Edit   Workspace   Options   Control   Glyphs   Help

▣ Create Procedure
▣ Create Count Loop
▣ Create While Loop

Create Expression
Create If Else
Create Merge Paths
Create Switch
Create Trigger

Workspace GUI
Export Selections
Encapsulate Workspace

MainWorkspace

Power Mac HD

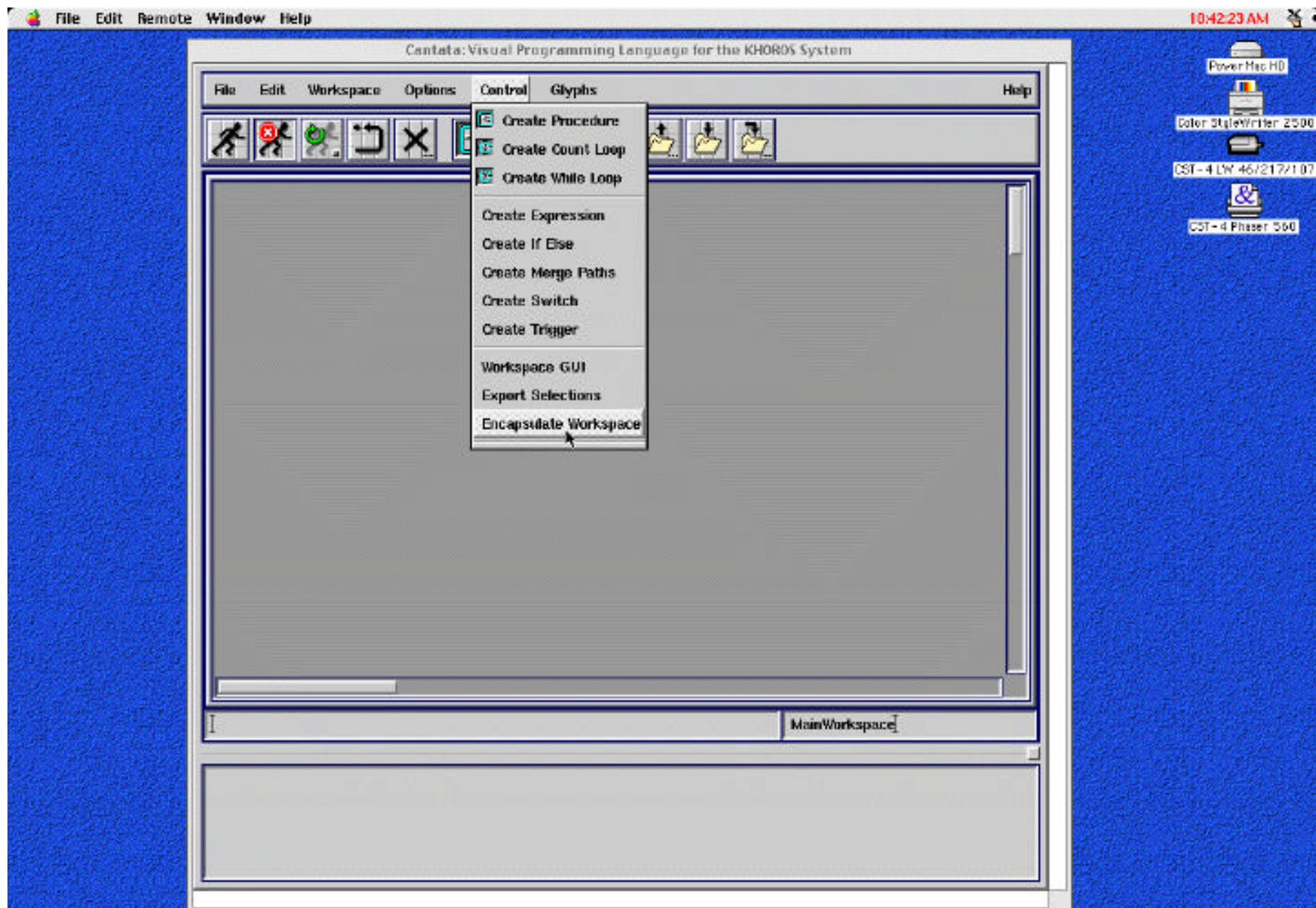Color StyleWriter 2500

CST-4 LW 46/217/107

CST-4 Phaser 560

Transportation Program

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Transportation Program

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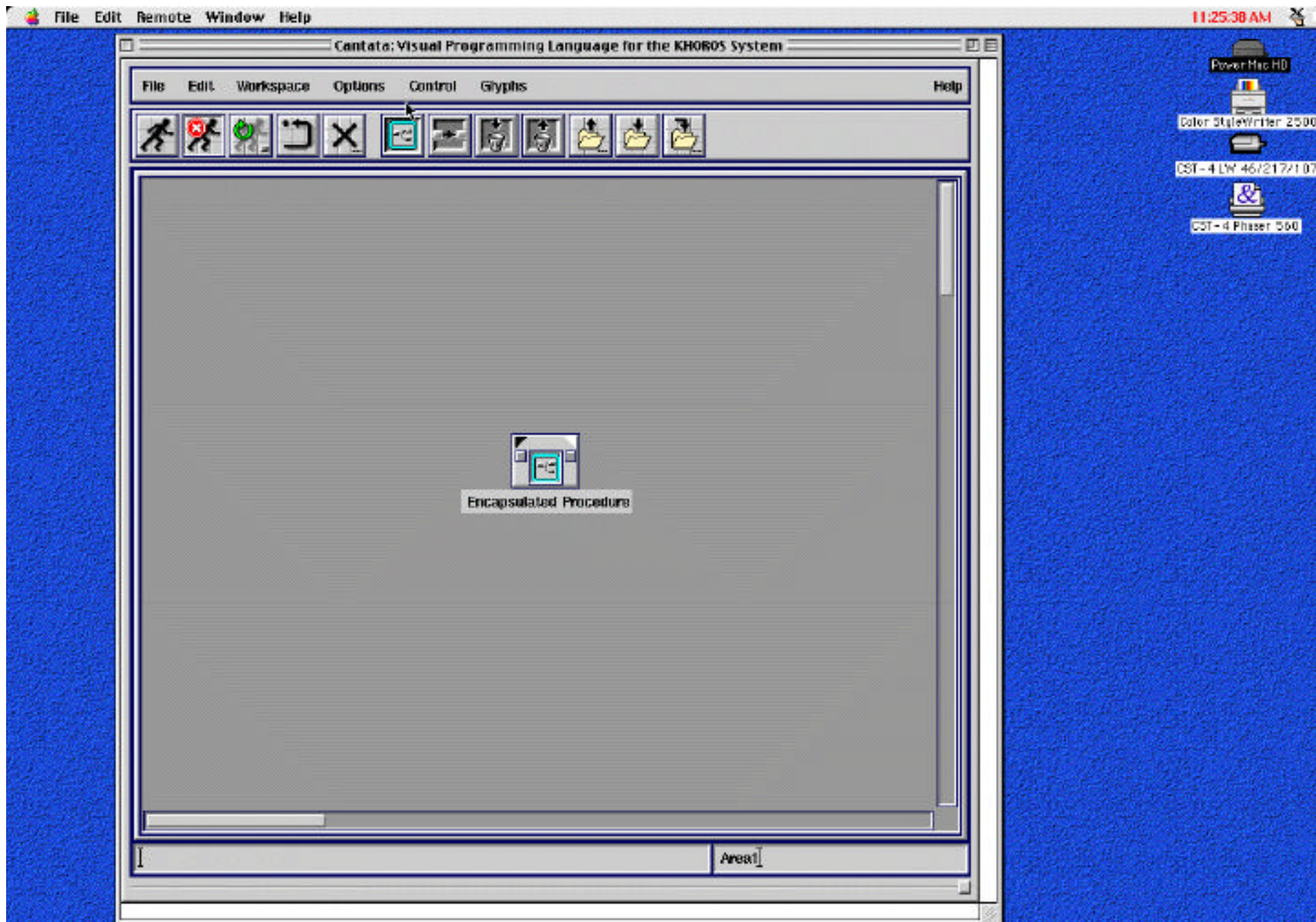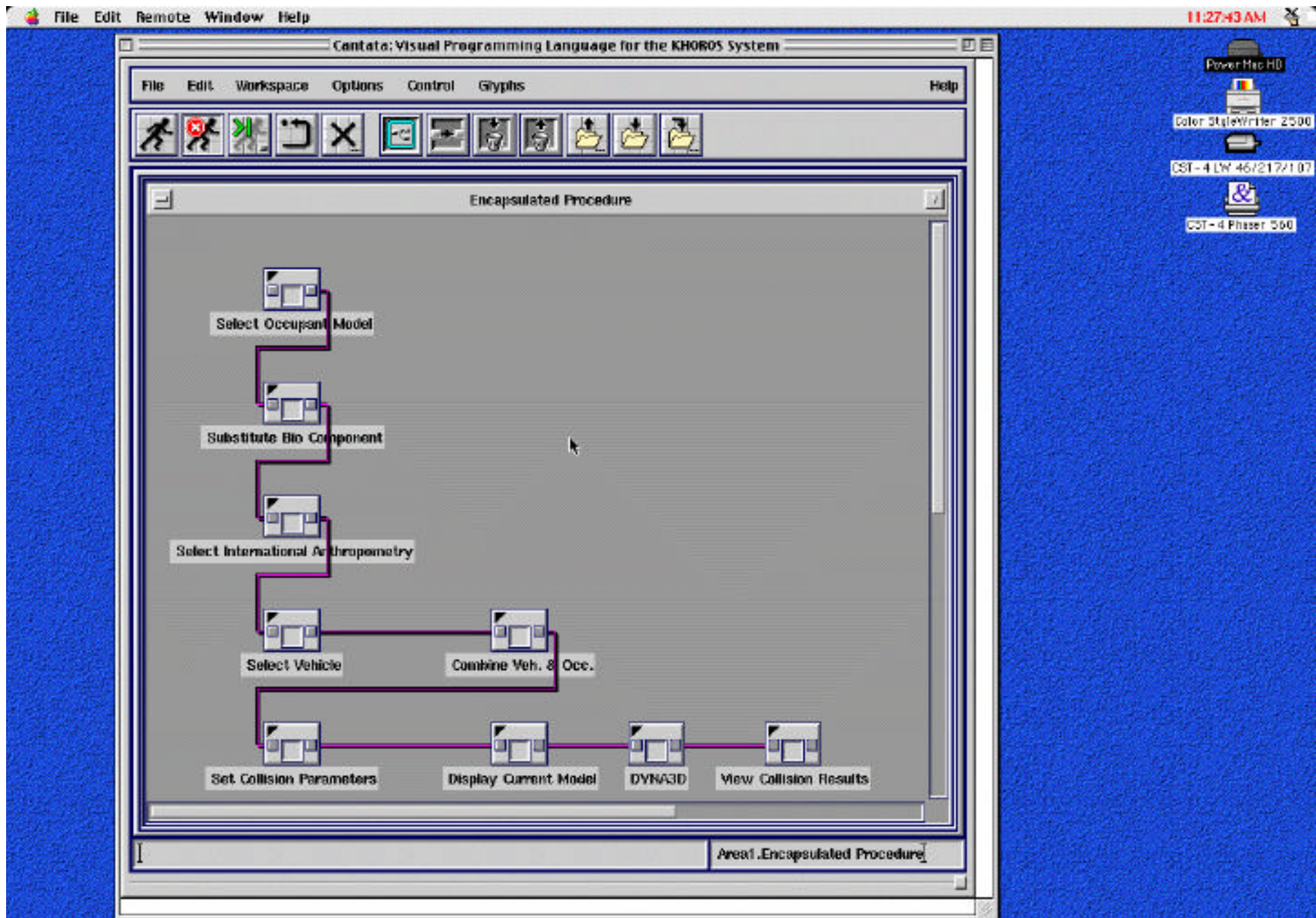
Current Deficiencies in Version 1 of NCAC Hybrid III Dummy Model

- **Most of lower body is composed of thin shells**
- **Pelvis is not connected to lumbar spine**
- **Some dummy components overlap in space**
- **Many materials have very unrealistic densities**
- **Many highly distorted elements**

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Future VSL Development Tasks

- **Finish NCAC Hybrid III Dummy Model (or incorporate other dummy model into VSL)**
- **Make "DYNA3D" and "Display Animated Results" glyphs operational**
- **Incorporate calculation of injury criteria**
- **Validate with crash test data**
- **Install at auto design/manufacture facility**

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Suggested Collaboration Strategies

- **Seek DOE/Transportation support for completion of basic VSL at Los Alamos (to be available to all manufacturers)**

  or

  Share funding for basic development of VSL with DOE/LANL through technology maturation project

- **Individual Manufacturer collaborations with Los Alamos and Khoral Research for implementation of VSL at specific facilities**

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